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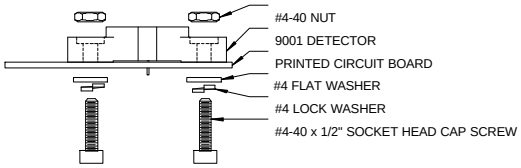
Jameco Part Number 181614

Introduction

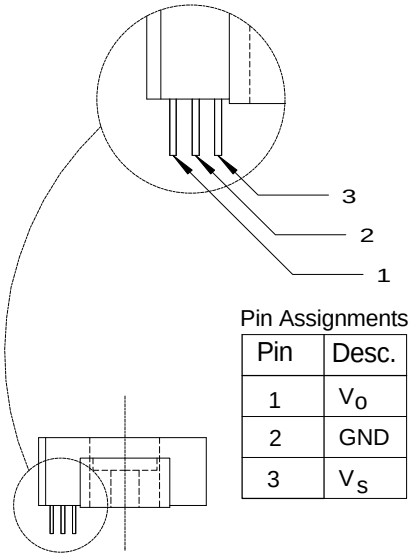
The IsoSense over current detector is designed to protect power electronic circuits by signaling when current in the circuit has exceeded the nominal detector trip point. The detector is designed to be mounted on a printed circuit board and provides an open collector output for connection to the circuits control circuitry. In order to insure that the detector operates reliably and accurately, the end user must mount and connect the detector properly in the circuit assembly. This note provides guidelines for mounting and connection of the detector.

Mounting

The detector is designed to be fixed to a printed circuit board (PCB) with two 4-40 machine screws using lock washers. These screws should be positioned with their heads below the PCB and the threads running up through the PCB and the two 0.115" mounting holes of the detector. Lock and flat washers should be used as shown in the figure below. The detector body has two nests molded above the 0.115" holes designed to capture 4-40 nuts. If the application environment is harsh in which high levels of vibration are expected, a thread locking adhesive should be applied to the mounting screw threads.



The output pins, V_o(O), GND(-), and V_s(+) are designed for soldering to through holes on a printed circuit board. The conductor carrying the current to be sensed must pass through the aperture of the detector. If a wire is used, the wire can be soldered to a pad on the PCB located within the aperture of the detector. Another option is that the wire be routed through the aperture and then through a clearance hole in the PCB to be terminated to another pad on the PCB or point within the assembly. In either case, care should be taken in the design to insure that no significant force is exerted on the detector by the current conductor. A third option is to use an optional busbar provided by IsoSense that routes the current through the aperture of the detector. The busbar is designed to straddle the detector. In this case a pad would be located on the PCB along the outer perimeter of the detector. A second pad would be located within the aperture. The busbar is designed to provide a simple means to route current on the PCB through the detector.

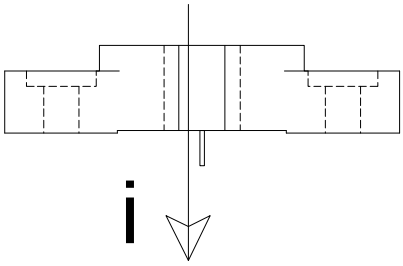


Pin Assignments

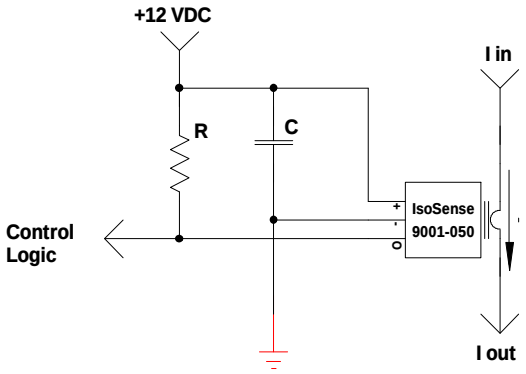
Pin	Desc.
1	V_O
2	GND
3	V_S

Electrical Interface

There are two sets of connections which must be made with the detector. The "input" set of connections consists of routing the current to be sensed through the aperture of the detector. In addition to the notes listed under mounting, the correct sensed current polarity must be observed. Since the detector is unidirectional, the detector can only sense over currents of one polarity. The proper polarity is defined by viewing the detector as if it were mounted on the PCB. Positive current is defined as current which flows down through the aperture of the detector to the PCB. The detector will only trip if a positive current exceeds the trip point.



The output of the detector is not designed to directly interface with the power transistors in the power circuit. Typically, it will interface with the control logic circuit, and this circuit will decide when and for how long the power device should be turned off. The output set of connections is made via three pins labeled V_o, GND, and V_s on the data sheet. These pins are also labeled O, -, and + on the top of the part. V_s and GND are the power supply connections for the detector. The detector will operate with DC voltages of 3.8 to 24 VDC. However, since most power circuits generate significant noise, IsoSense recommends operating at a supply voltage which provides significant margin from either extreme. A 12 VDC supply is ideal. Additionally, a 0.1µF AC decoupling capacitor, C, should be used to provide good noise decoupling to the supply pins. The output pin, V_o, is an open collector output capable of sinking 20 mA. The output is normally open and goes low when the detector trip point is exceeded. The typical interface will have a 5.1kΩ pull up resistor, R, connected from the output to the supply voltage of the interface circuitry. A capacitor can be connected from GND to the output to maximize noise immunity. If a capacitor is used, its value should be minimized so that the output of the detector continues to switch fast to provide maximum protection against over current events.



Introduction

The IsoSense over current detector has been designed with the intended application of protecting power semiconductors in power electronic circuits. As such, its application is not limited to one type of power circuit, but instead circuits where power semiconductors are used. It combines small size, an isolated output, and fast response time with a low price to provide a very effective means for protecting power semiconductors against over current conditions. This application note is intended to illustrate application of the detector in typical power electronic circuits. It is not intended to be an exhaustive illustration. However, it does provide some common examples which should facilitate application to other power circuits. For more detailed information on mounting recommendations and electrical interface, please consult application note AN-101.

Detector Highlights

The IsoSense over current detector is an ideal choice for over current sensing in today's sophisticated power electronic circuits. The over current detector provides isolation between the sensed current and the output signal. An isolated power supply is not required to power the sensor, even when sensing current which is above or below the ground potential. It has a digital open collector type output which goes low when the current exceeds the detector trip threshold. Because this is a digital output, it is easily filtered with only a very small effect on the response time of the output signal. Thus, over current conditions are typically signaled in 1 μS, providing plenty of headroom for system control circuitry to protect the power circuitry. Since the detector is Hall effect based, it has a negligible level of power dissipation. This remains true in high frequency switching circuits as well.

Comparison to Current Shunt Sensing

Current shunt sensing is used in many existing power electronic circuits. This method passes the sensed current through a resistor. The voltage across the resistor is then compared to a reference in a comparator or op amp to determine if the current has exceeded a safe threshold. The chief advantage of this method is that it is simple and relatively low cost particularly at low power levels. However, it also comes with some problems. First, it does not provide isolation and so it is typically used to measure current in the ground bus. If measuring current at any other voltage potential, an isolated power supply and signal interface is required. Second, even if used in the ground bus, as current levels and switching speeds increase, the shunt generates significant levels of conducted EMI which can have an adverse impact on sensitive control circuitry. Third, noise generated across the shunt requires filtering which slows the response time of the detection circuit. Fourth, the size of the shunt can often preclude mounting on the printed circuit board. This, in turn increases assembly time and labor costs and can have a negative impact on the quality level. Finally, the power dissipated in the shunt becomes a more significant problem at higher current levels. All of these problems are significantly reduced or eliminated entirely with the IsoSense over current detector. And this is done at a price point which makes it a competitive choice for sensing over currents at much lower power levels than was previously possible with other more expensive magnetic type sensors.

Circuit Examples

1 - 3 Phase Inverter

A schematic of a three phase inverter is shown in figure 1. In this circuit, current must be sensed in the bridge to protect the power transistors against over current conditions. The over current conditions can be caused by transient loads on the output of the inverter, or shoot through conditions caused by noise in the control circuitry or intermittent logic problems. In an ideal world, a sensor would be used on each transistor or at least on each phase or pole of the inverter. But this is difficult to justify from a cost perspective, even with the cheapest of sensing solutions. A good compromise between cost and reliability is to sense current in the ground bus.

The schematic shows the over current detector in the ground bus. The output of the detector is connected to the circuits control logic. In the case of an over current event, the control logic shuts down the bridge for a programmed off time period via the drive signals to the

transistors. Often this shutdown period only needs to be ~100 µS. By having a short off time, the shutdown of the bridge is almost imperceptible to the outside observer. The control circuit can be designed to count over current events within a window of time. A high number of events is indicative of an over load condition, or even a failed transistor within the bridge. In this case, the bridge can be shutdown for service. This prevents catastrophic destruction of the inverter and facilitates a much quicker determination of the root cause of the problem.

2 - Single Phase Inverter

A schematic of a single phase inverter is shown in figure 2. This application is similar to the three phase inverter. In this case, the detector is shown in the positive bus to the bridge, although it could have just as easily been placed in the ground bus. It makes no difference from a circuit perspective. However, from a packaging perspective, it provides some flexibility. This flexibility in placement can prove to be a big advantage during the printed circuit board layout phase of the design.

3 - Single Phase Inverter with Parallel MOSFET's

A schematic of a single phase inverter with paralleled FET's is shown in figure 3. In this circuit two FET's are paralleled to form each switch group. In this case, as in the previous two, the detector could be placed in either the positive or negative buses. The problem with this is that the detector and the conductor passing the sensed current must be rated for the entire bridge current. A more economical approach is to locate the detector so that it senses the current in one FET from each of either the top or bottom switch groups. The schematic shows this for the top case. This approach provides a relatively small detector to be used even for bridges that might parallel 10 or 12 transistors per switch group. It also works very well with FET's since they share current very well.

4 - High Frequency Half Bridge Converter

A schematic of a high frequency half bridge IGBT based converter is shown in figure 4. In this schematic, two detectors are used to provide protection against over currents due a variety of conditions. These include shoot through, transformer saturation, output overload, and transient output conditions.

5 - Brush DC Motor Control

A schematic of a brush DC motor drive is shown in figure 5. In this case the detector can be located in the positive bus, between the negative side of the motor and the FET, or in the negative bus. All three locations provide equivalent protection. Again, the placement of the detector may be dictated by space considerations during the printed circuit board layout phase of the design.

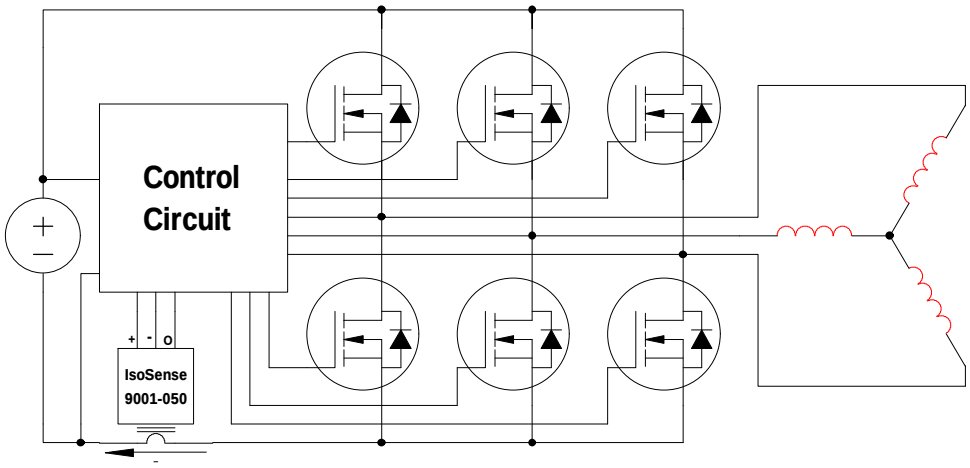


Figure 1, 3 Phase Inverter Schematic

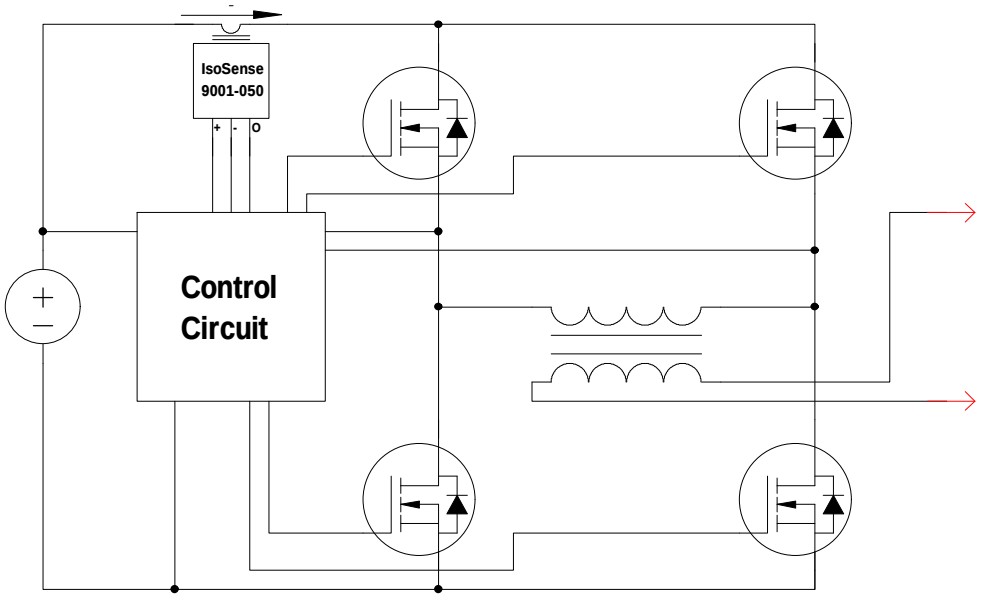


Figure 2, Single Phase Inverter

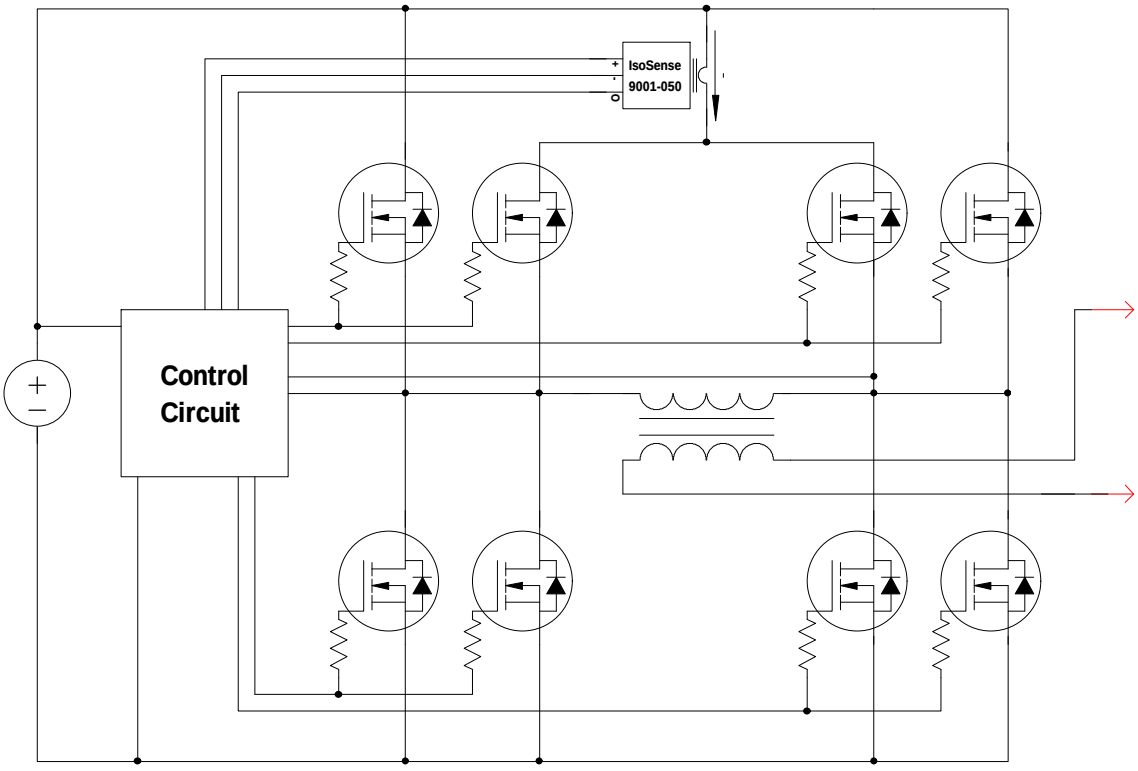


Figure 3, Single Phase Inverter with Paralleled FET's

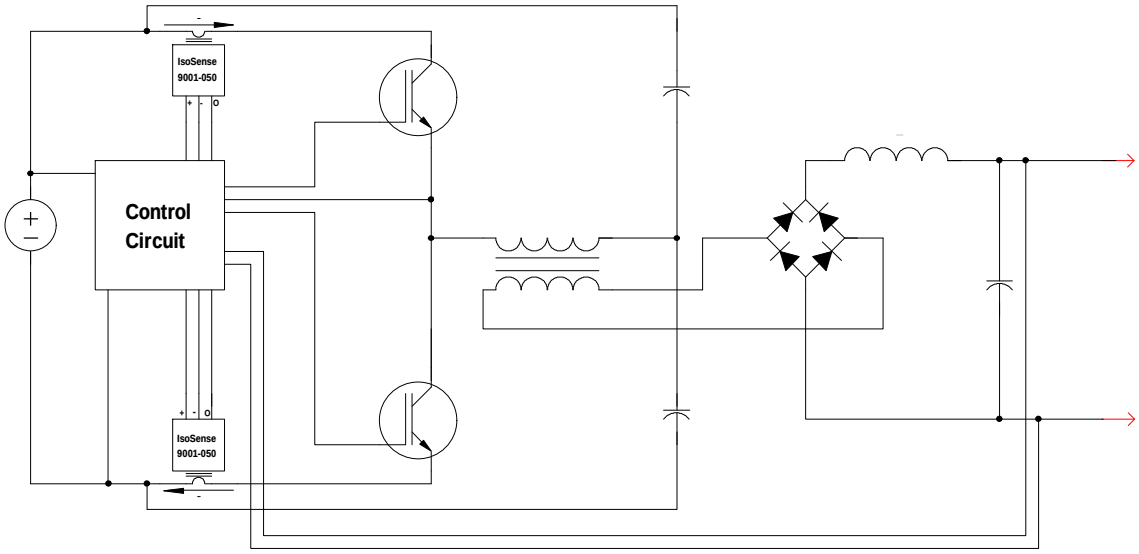


Figure 4, Half Bridge IGBT Based Converter

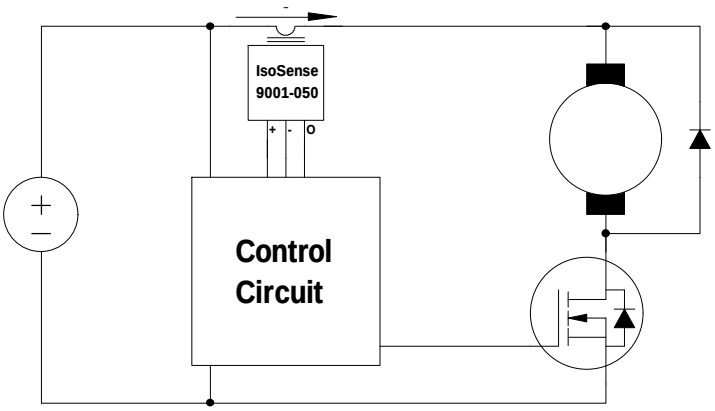


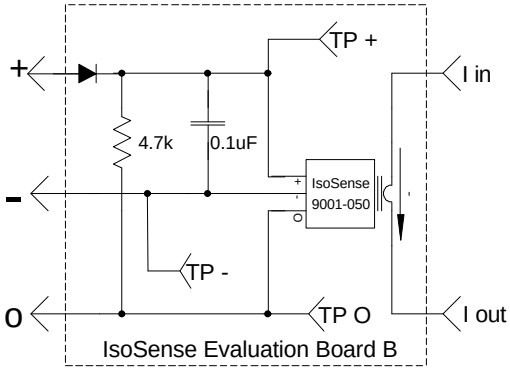
Figure 5, Brush DC Motor Control

Introduction

In recognition of the limited time that design engineers have to evaluate new components, IsoSense has developed several evaluation board assemblies. These evaluation boards facilitate evaluation of IsoSense's family of OCD's (Over Current Detectors) in a customer's application with minimal modification and time requirements. This application note details the connection of the B evaluation board.

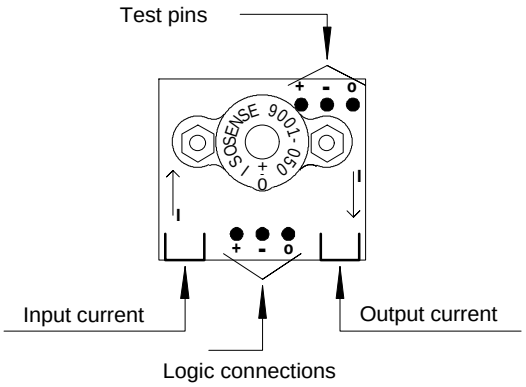
Operation

The IsoSense OCD is a Hall effect type current sensor with a digital output signal. Currents exceeding the detectors threshold cause the detector's open collector output to go low. Currents below the threshold force the output to be high or open. The B evaluation board is made up of an OCD with a power supply decoupling capacitor, an output pull up resistor, test pins, and input and output connections. The board is designed to be connected into a functional circuit with minimum modification.



Connection

Five electrical connections are required for the evaluation board. These can be divided into the sensed current set and a logic set. The two sensed current connections connect the current to be sensed to the board. These connections are made via the two ring terminal screw connections. The OCD is unipolar so the correct polarity must be observed and is indicated with arrows on the board next to the terminals. Incorrect polarity will not damage the detector, however currents exceeding the OCD's trip point will not be detected as over current events if the polarity is incorrect. In many applications, currents to be sensed are already conducted through a lead wire. In this case, the lead wire will need to be cut and ring terminals added to the two ends for connection to the evaluation board. In other cases, the current to be sensed may be routed through a PCB (printed circuit board) trace or busbar. In these cases, the conductor will have to be cut and lead wires attached for routing to the evaluation board. For evaluation of currents in leaded transistor packages, it is often easiest to pull one of the power leads from the PCB and connect lead wires from the interrupted connection to the evaluation board. In all cases, try to keep the leads as short as possible to minimize leakage inductance.



Three signals make up the logic set of connections. Two of these signals are for the DC supply to the detector. These connections are indicated with a + and - along the edge of the PCB between the two screw terminals. Connect a supply with a DC voltage between 5 and 18 volts to these connections observing the indicated polarity. The current for the power supply is ~10mA. The third connection is for the open collector output of the detector. The connection is indicated with a o next to the - connection. This connection is pulled up to the positive supply on the evaluation board with a 4.7 kΩ resistor. This connection should be connected to the over current shutdown input in the application circuit. Some modification may be required to invert logic, or not exceed the operating limits of the open collector output. This output can sink 10 mA when low. The voltage on the output should not exceed 18 volts.

Mounting

This evaluation board is only intended for evaluation in an engineering lab. Although mounting is not critical for evaluation, it is important for safety concerns. Since the board will have electrical connections operating at different voltage potentials, caution must be observed to insure that none of the board circuitry touch other circuitry or personnel in the end application. Extra care should be taken to insulate the evaluation board assembly when the current to be sensed is at any potential above ground.

This evaluation board is not intended for any other use but evaluation of IsoSense's family of OCD's in an engineering laboratory. When used in production designs, the OCD should be mounted directly to the application's printed circuit board. Refer to AN-101 for mounting suggestions. Refer to AN-102 for ideas on connection to a variety of power circuits.

IsoSense inc. 9001 Series Over Current Detector Data

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	-1.0 to +25 VDC
Voltage externally applied to output	+25 VDC max (Output high, current below I_{trip}) -0.5 VDC min (Output high or low)
Output ON current (sink)	50 mA
Operating Temperature Range	-40 °C to +125 °C
Sensed Current	+/- 500 Amps peak

Absolute maximum ratings are the extreme limits that the detector will withstand without damage. Electrical operation and characteristics are not guaranteed as the maximum limits are approached. Proper application of the detector must insure that the detector operates within the operating characteristics listed below.

OPERATING CHARACTERISTICS

	Symbol	Min.	Typ.	Max.	Notes
Supply Voltage	V_s	3.8		24.0	VDC
Supply Current	I_s			10.0	mA
Operating Temperature	T_{op}	-40		125	°C Note 1
Output Trip Time	T_{trip}		1.0	2.5	µS, di/dt=Itrip/uS
Output ON Voltage	V_{os}		0.15	0.40	VDC sinking 20 mA
Output ON Current	I_{os}			20	mA
9001-050 Trip Current	I_{trip}	44.0	50.0	56.0	Amps @ 25 °C
9001-075 Trip Current	I_{trip}	66.0	75.0	84.0	Amps @ 25 °C
9001-100 Trip Current	I_{trip}	88.0	100.0	112.0	Amps @ 25 °C
9001-125 Trip Current	I_{trip}	110.0	125.0	140.0	Amps @ 25 °C
9001-150 Trip Current	I_{trip}	132.0	150.0	168.0	Amps @ 25 °C

Note 1: See application note AN-101 for severe duty mounting requirements

Figure 1
9001-050 Trip Current vs. Temperature

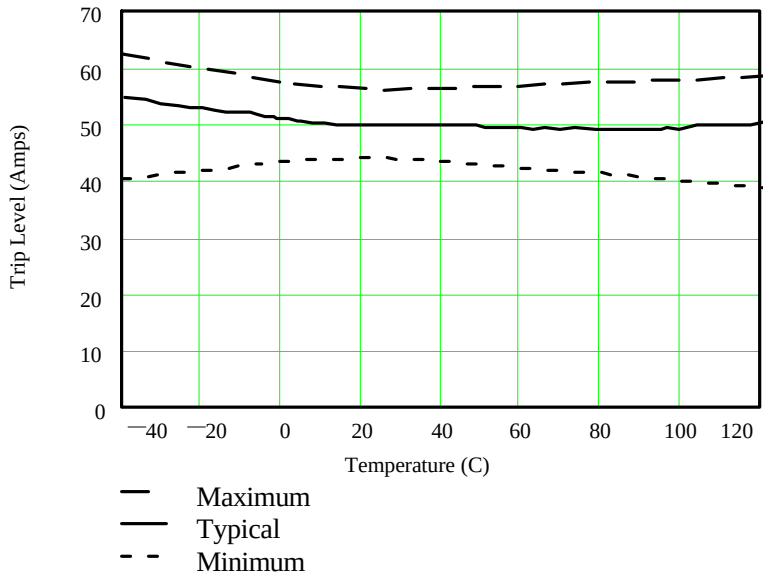


Figure 2
9001-075 Trip Current vs. Temperature

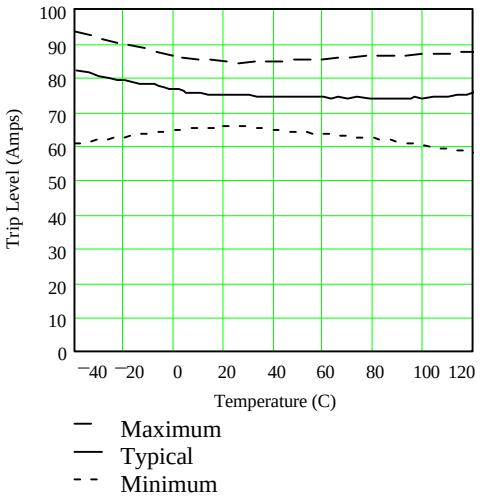


Figure 3
9001-100 Trip Current vs. Temperature

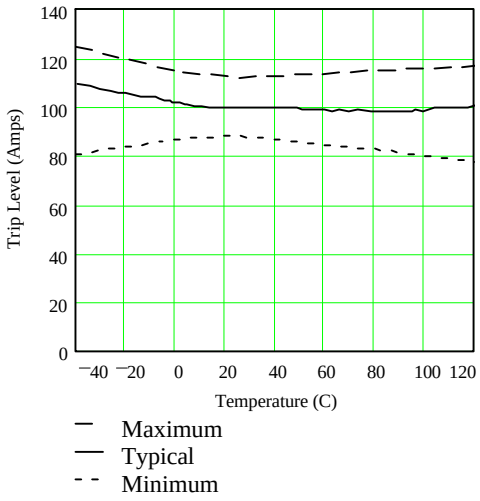


Figure 4
9001-125 Trip Current vs. Temperature

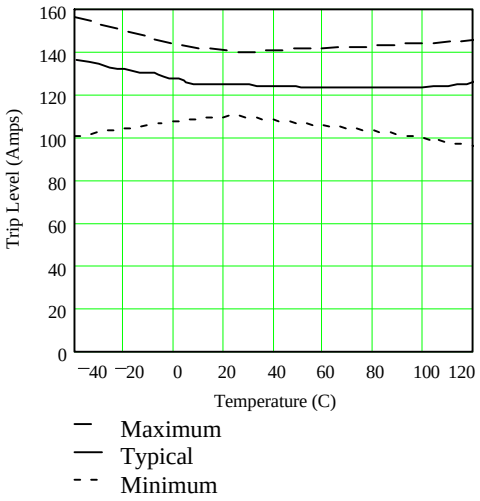
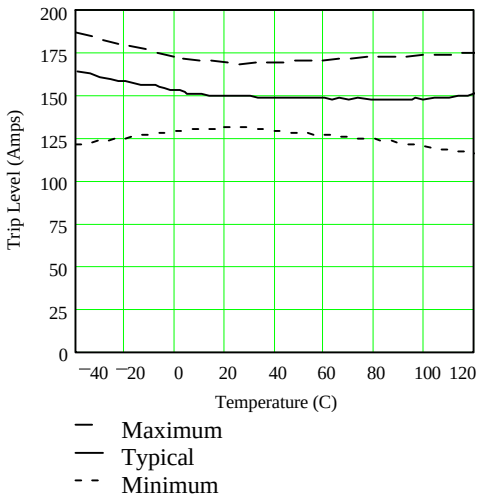
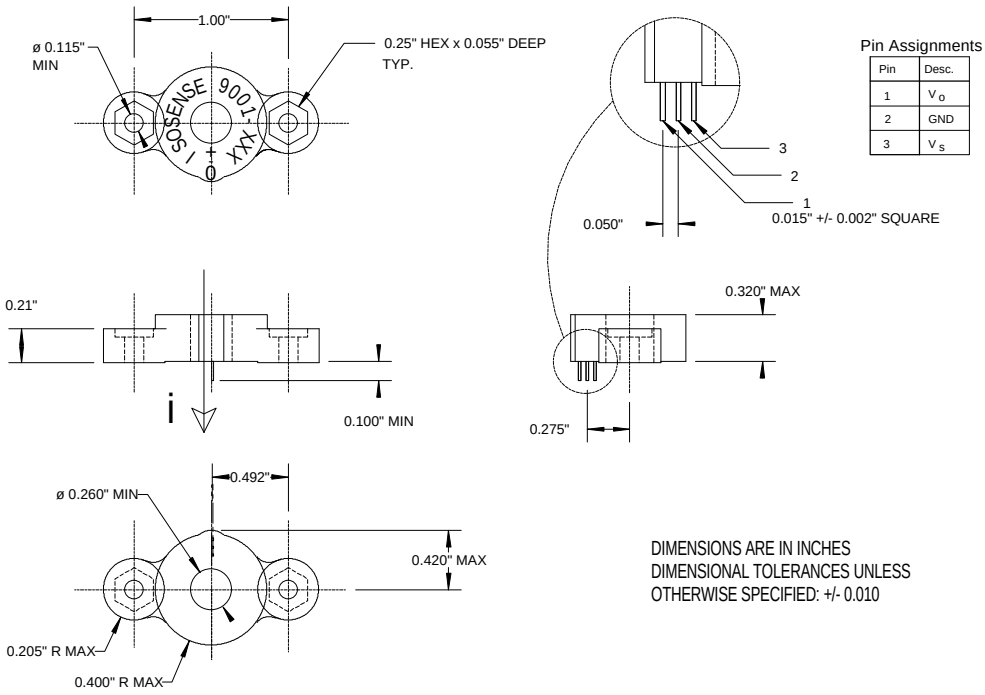


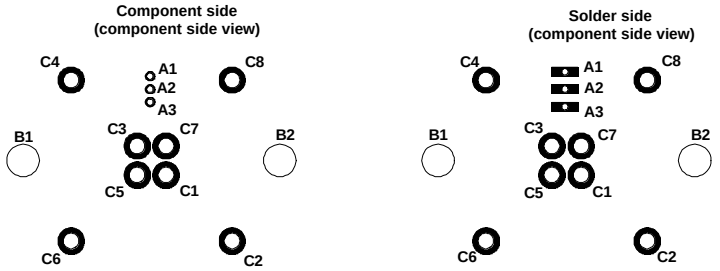
Figure 5
9001-150 Trip Current vs. Temperature



MECHANICAL DIMENSIONS



PRINTED CIRCUIT BOARD MOUNTING FOOTPRINT

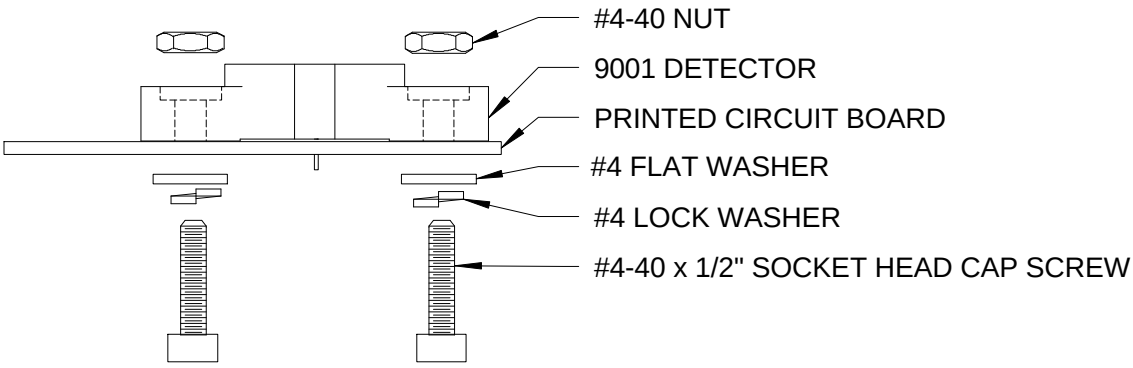


Hole Location Chart		
Hole	X	Y
A1	-0.008	0.325
A2	-0.008	0.275
A3	-0.008	0.225
B1	-0.500	0.000
B2	0.500	0.000
C1	0.056	-0.056
C2	0.311	-0.311
C3	-0.056	0.056
C4	-0.311	0.311
C5	-0.056	-0.056
C6	-0.311	-0.311
C7	0.056	-0.056
C8	0.311	-0.311

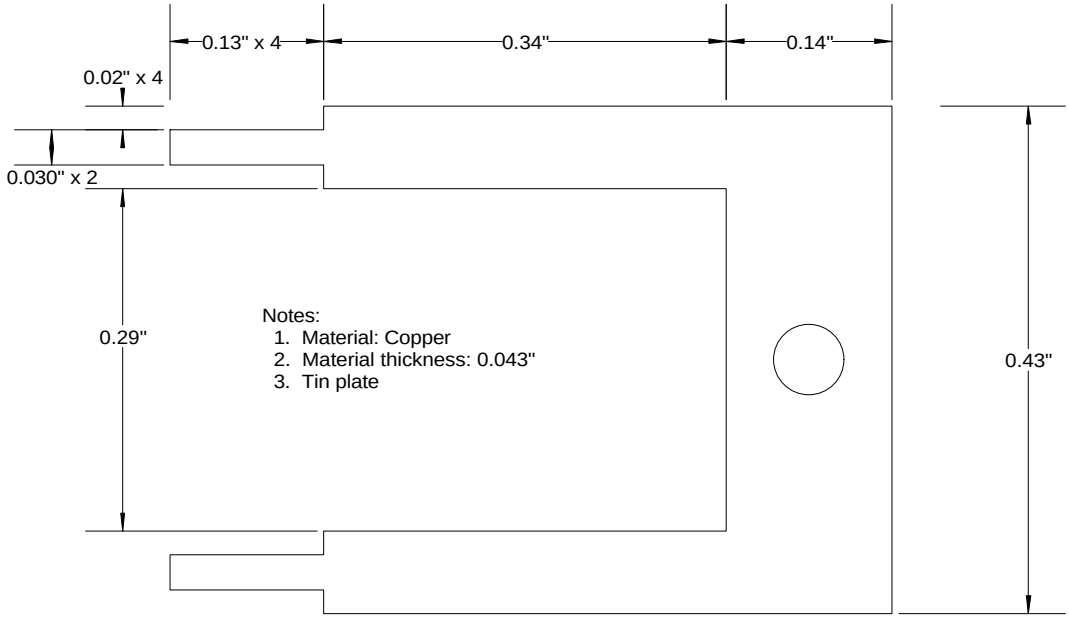
Hole Description Chart			
Hole	Finished diameter	Top Pad	Bottom Pad
A	0.027	0.035	0.035 x 0.100
B	0.136	None	None
C	0.060	0.100	0.100

Notes:
1. B holes for 4-40 mounting screws.
2. C holes for optional accessory busbars (part number 9002-001).
3. Center aperture of detector located at X=0.000, Y=0.000.
4. Hole diameter tolerance +/- 0.003.
5. Hole location tolerance +/- 0.003.

MOUNTING EXPLODED VIEW



9002-001 ACCESSORY BUSBAR MECHANICAL DIMENSIONS



PART NUMBERS

Part Number	Description
9001-050	50 Amp over current detector
9001-075	75 Amp over current detector
9001-100	100 Amp over current detector
9001-125	125 Amp over current detector
9001-150	150 Amp over current detector
9002-001	Accessory Busbar
9002-200	Nylon socket head cap screw mounting set
9002-300	Steel socket head cap screw mounting set

Introduction

The IsoSense over current detector (OCD) is uniquely designed to enhance the reliability of power conversion circuits. It quickly senses over current events using a Hall effect approach. The detector is supplied in a small, isolated, zero insertion loss, printed circuit board mountable package that can be operated from -40°C to 125°C. In order to demonstrate the effectiveness of the OCD, a test circuit has been constructed simulating the most severe operating condition for a power transistor. This condition is for a power transistor switching directly into a shorted output and operating at high frequency.

Test Circuit Description

The test circuit can be split into two sections. The first section is the power or high current portion of the circuit. The second section is the control or logic section of the circuit. The power section consists of a 20 volt DC power supply connected in series with an N-channel MOSFET, a sense resistor and the IsoSense 50A OCD. For this test, a IRFZ44E MOSFET was chosen. This is a 60 volt, 48 amp, 23 mΩ part. It was chosen because it is considered to be representative of 40-60 amp, 60 volt MOSFET's which have been available for several years. The connections between the power supply and the rest of the circuit consisted of 20 gage leads 8 inches long. In order to minimize the effect of the impedance of the power supply leads, a 3300µF capacitor is included directly on the test board. The total length of the power traces and leads in the test circuit connecting the MOSFET to the sense resistor, capacitor, and OCD is 5 inches.

The logic section of the circuit consists of a micro controller driving the clock input of a D flip flop with the output of the flip flop driving a MOSFET gate driver. The output of the OCD is fed back to clear the flip flop which turns the MOSFET gate drive off when an over current event is detected. Figure 1 shows a combination schematic and block diagram for the power and logic sections respectively.

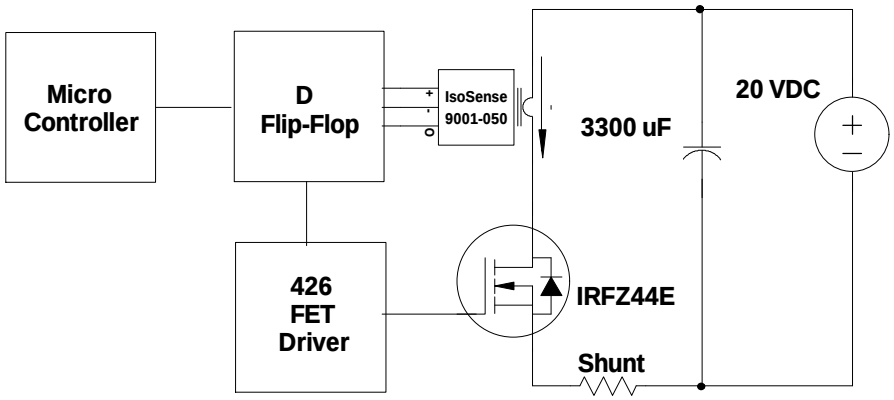


Figure 1, Test Circuit Schematic - Block Diagram

Test Results

This circuit was operated over frequencies ranging from 100 Hz to 30 kHz. In all cases the OCD provided very effective protection for the MOSFET. While operating at frequencies at or below 1000 Hz, the circuit could be run continuously without interruption. As the frequency was increased, the MOSFET temperature would climb to an unacceptable level if the circuit was operated continuously. This can be attributed to the switch and conduction loss associated with operating the MOSFET into a direct short. The power loss in this case climbs directly with the operating frequency. The condition was further aggravated by the fact that a minimal heatsink was used on the MOSFET. Even with this minimal heatsink, the circuit could be operated for a minimum of 10 seconds all the way up to 30 kHz before a heatsink temperature of 80 °C was achieved.

In a real circuit application, with a heatsink designed for typical operating conditions, the MOSFET could be expected to operate at a higher frequency or for a longer period of time into the direct short. In addition, a more intelligent logic circuit could be designed to simply count over current pulses over a window of time. A large number, indicative of a short condition, could be used to shut down the circuit either temporarily or permanently.

The MOSFET and OCD operating waveforms are shown in figures 2 and 3 with the circuit operating at 10 kHz. In these plots, waveforms are numbered 1 - 4 from the bottom to the top. Trace 1 is the gate to source voltage at 10 V/div. Trace 2 is the drain current measured by measuring the voltage across the 10 mΩ shunt at 1 volt/div (= 100 amps/div). Trace 3 is the drain to source voltage at 20 V/div. And trace 4 is the OCD output at 5 volts/div.

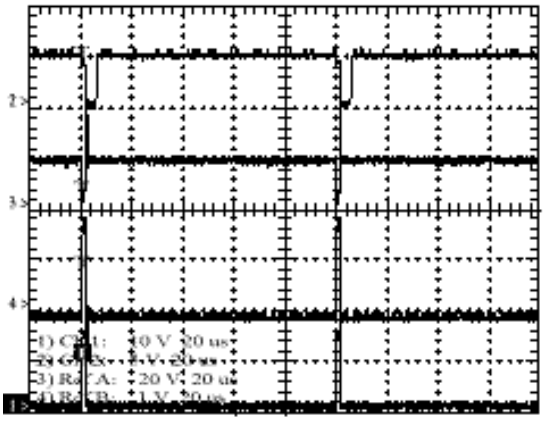


Figure 2, Test Waveforms at 10kHz, 20mS per Division

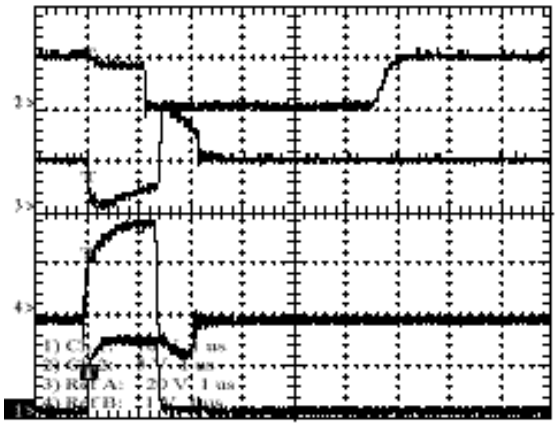


Figure 3, Test Waveforms at 10kHz, 1mS per Division